ECOLOGICAL VALIDITY OF SESSION RPE METHOD FOR QUANTIFYING INTERNAL TRAINING LOAD IN FENCING

ABSTRACT

Session rating of perceived exertion (sRPE) is known to significantly relate to heart rate (HR) based methods of quantifying internal training load (TL) in a variety of sports. However, to date this has not been investigated in fencing and was therefore the aim of this study. TL was calculated by multiplying the session rating of perceived exertion (sRPE) with exercise duration, and through Heart rate (HR) -based methods calculated using Banister's and Edward's TRIMP. Seven male elite foil fencers (Mean ± SD: Age = 22.3 ± 1.6 years, height = 181.3 ± 6.5 cm, body mass = 77.7 ± 7.6 kg) were monitored over the period of one competitive season. The sRPE and HR of 67 training sessions and three competitions (87 poule bouts and 12 knockout rounds) were recorded and analysed. Correlation analysis was used to determine any relationships between sRPE and HR-based methods, accounting for individual variation, mode of training (footwork drills vs. sparring sessions) and stage of competition (poules vs. knockouts). Across two footwork sessions, sRPE, Banister's and Edward's TRIMP were found to be reliable, with coefficient of variation values of 6.0, 5.2 and 4.5% respectively. Significant correlations with sRPE for individual fencers (r = 0.84 – 0.98) and across mode of exercise (r = 0.73 – 0.85) and competition stages (r = 0.82 – 0.92) were found with HR-based measures. sRPE is a simple and valuable tool coaches can use to quantify TL in fencing.

Key words: Epee; foil; sabre; monitor; TRIMP

INTRODUCTION

Although each fencing training day will vary based on temporal objectives, training normally consists of a group warm up, technical work and several bouts of sparring. The combative nature of fencing however, makes it difficult to assess exercise intensity and subsequently training load using the standard method of heart rate (HR) monitoring – where HR is multiplied by the session duration to reveal the training impulse or TRIMP.[1] This is because HR is considered a relatively poor indicator of short duration, high intensity exercise, due to the insignificant stress on the cardiovascular system.[2-4] This causes great difficulties for coaches when attempting to quantify and prescribe training loads, which is of concern as this practice is required for peak performance[5,6] and the reduction of injury, illness and risk of overtraining.[2,7] While adjustments to HR based methods have been made (e.g., the "modified TRIMP" and "lactate threshold zone" method) to accommodate these drawbacks (e.g., measuring time spent in each heart rate zone multiplied by a relevant weighting factor),[4] it is still not suitable for fencing, as anecdotal experience reveals that HR monitors are regularly damaged due to continuous hits from the sword and thus testing in team environments can prove costly and time consuming. They are also not appropriate measures of training load (TL) for many strength and conditioning based activities such as resistance training and plyometrics,[8-10] thus eliminating the use of one standardised metric across all training modes. These issues underpin the need for an alternate method, which coaches could use to accurately and reliably calculate TL. Subsequent to such issues being raised in other sports, a TL quantification method, using the session rating of perceived exertion (sRPE; a 10-point rating of perceived exertion), multiplied by the duration of the exercise session was developed[11,12] and is considered valid on account of its high correlation (r = 0.75–0.90) with TRIMP-based methods.[4] This association has been shown in and subsequently implemented in, various team sports[13-18] taekwondo,[19] swimming,[6] boxing[20] and sprint kayak[21] for example. As of yet however, there have been no studies to examine the use of the sRPE method as a tool to quantify TL in fencing. Therefore, the aim of this study is to compare the sRPE to modified TRIMP methods of quantifying TL, in both training and competition settings. It is hypothesised that similar to other sports, strong associations will be found between the two observed methods.

METHODS

Subjects

Seven elite male fencers took part in the study. On average (mean ± SD), they were 21.8 ± 2.3 years of age, 179.2 ± 5.5 cm tall, 74.2 ± 6.4 kg in mass, and had 14.3 ± 3.6 years fencing experience; they were healthy and free from injury. All fencers trained full-time, typically 5 days a week (usually 0930 – 1500), with training usually consisting of a standardised warm-up (30 - 45 min), footwork (30 - 45 min) and sparring (90 - 120 min), and at least three resistance training sessions (45 - 60 min each) and two conditioning sessions (15 – 30 min) a week. During preseason, a one-month familiarisation period was provided to help the athletes become acquainted with the modified RPE Borg-scale and heart rate monitoring procedures. The Middlesex University Ethics Committee, in the spirit of the Helsinki Declaration, granted approval for the study and each participant provided written informed consent before taking part in the research.

Experimental approach and Study Design

This study was completed throughout the duration of one competitive season, in the build up to the 2016 Rio Olympics. As well as during training sessions, HR's and sRPE's were recorded across three competitions and divided to define poule and knockout bouts. In total, 67 training sessions were analysed, 85 poule bouts and 12 knockout rounds. Correlations were also assessed across each type of fencing session (e.g., footwork drills and sparring) to ensure its compatibility across all modes of training. Correlations between variables were analysed on an individual athlete basis, as well as grouped together as a squad. Within-individual analysis ensured it was a suitable method for all, thus supporting its use as a means to individualise training programmes. To examine the reliability of each method used to quantify TL, two identical footwork sessions where compared to each other. These sessions were performed on a Monday, following two days off and a light tapered training day on the Friday previous. This was to ensure athletes were as rested as possible, thus avoiding the confounding effects of residual fatigue and muscle soreness that may otherwise vary between sessions. Furthermore, this was completed within a two-week period to avoid significant adaptations in each fencer, whereby identical sessions would require relatively less exertion given improvements in fitness.

Quantifying Training Load

Session Rating of Perceived Exertion. TL was calculated using the sRPE method proposed by Foster *et al.*[4] and involved multiplying the total duration of a bout or exercise session in minutes by the training intensity; the latter was measured by a modified version of Borg's CR-10 scale[22] of perceived exertion, referred to sRPE (See Table 1). The sRPE score was obtained from the athletes approximately ten to 30 minutes after each bout or exercise session, and typically following the cool-down.[20] This was in response to the question "*how hard was your workout?*" TL is then expressed as a single value in arbitrary units (AU).

Table 1. Session RPE scale[11]

	Session RPE
0	Rest
1	Really easy
2	Easy
3	Moderate
4	Sort of hard
5	Hard
6	
7	Really hard
8	
9	Really, really hard
10	Just like my hardest race

Heart Rate. Each athlete was also provided with a Polar Team$_2$ Pro HR-monitor (Polar Electro Oy, Finland) to measure exercise intensity during bouts and exercise sessions. Resting HR's were determined by instructing athletes to lie on the floor for ten minutes, the lowest heart rate observed during this time were deemed their resting HR. Max HR's were deemed the highest score recorded for the athlete in competition; these scores always surpassed that recorded in training. After each training session and competition, the HR data was downloaded from the transmitters onto a computer using the Polar Team$_2$ Software (Polar Electro Oy, Finland) and then exported into Microsoft excel (Microsoft Office 2007, Microsoft Corporation, USA) in order to calculate the TL's Banister's[1] and Edward's TRIMP[23] as described in Table 2.

Table 2. Training Impulse Calculations including example working outs

TRIMP[1]

$TRIMP = TD \cdot HR_R \cdot Y$

Where: TD = effective training session duration; HR_R = heart rate ratio; $HR_R = [(HR_{TS} - HR_B)/(HR_{max} - HR_B)]$; HR_{TS} = average training session HR; HR_B = HR measured at rest; HR_{max} = maximally measured HR; $Y = 0.64e^{b.HR_R}$; e = 2.712, b = 1.67 for females and 1.92 for males.

Example: First calculate the heart rate ratio (HR_R), using the session's average (HR_{TS}), resting (HR_B) and maximal (HR_{max}) heart rate and multiple this by training duration (TD) and the weighting factor (Y). Assuming HR_B = 70bpm, HR_{max} = 200bpm and HR_{TS} = 160bpm and TD = 30min then:

- HR_R = (160 – 70)/(200 – 70) = 90/130 = 0.69
- Then multiple HR_R by 30 = 20.7
- We can calculate Y separately and assuming the athlete is male, b in the equation = 1.92
- Y = 0.64 x 2.712 ^ (1.92 x 0.69), where ^ = to the power of
- Y = 2.34
- Therefore TRIMP = 20.7 x 2.34 = 48.44 Arbitrary units (AU)

Modified TRIMP[23]

Multiple the time (min) spent in each of the HR zones by its weighting factor.

Zone 1 = 50–60% of HR_{max} = weighting factor 1

Zone 2 = 60–70% of HR_{max} = weighting factor 2

Zone 3 = 70–80% of HR_{max} = weighting factor 3

Zone 4 = 80–90% of HR_{max} = weighting factor 4

Zone 5 = 90–100% of HR_{max} = weighting factor 5

For example, across a 30 minute session, this may look as follows:

(3*1) + (6*2) + (7*3) + (10*4) + (4*5) = 93AU

Statistical analysis

All statistical analysis was carried out using SPSS statistical package (v.21.0, SPSS Inc., Chicago, Illinois) with a statistical significance set at $p < 0.05$. All data is presented as mean ± standard deviation (SD) and measures of normality were assessed using the Kolmonogrov-Smirnov statistic. To determine the reliability of each assessment, single measures intraclass correlations (ICC; two-way random with absolute agreement) between trials were conducted along with determination of the coefficient of variation (CV). Pearson's product moment Correlation analysis was used to identify relationships between variables.

RESULTS

Across two identical footwork sessions, sRPE, Banister's and Edward's TRIMP had ICC values of 0.55, 0.69 and 0.73 respectively, and CV values were 6.0, 5.2 and 4.5% respectively. HR and sRPE's were collected from 67 training sessions and 101 competition bouts and significant within-fencer relationships between sRPE and both HR-based methods for TL were found (Table 3).

Table 3 – Individual correlations for each athlete, comparing TL calculated using sRPE to HR-based methods during fencing training (combined TL for footwork and sparring) and competition bouts (combined TL for poules and knockouts), significant at *$p < 0.05$, **$p < 0.01$, F = Fencer

	Training sessions (footwork and sparring)			Competition bouts (poules and knockouts)		
Fencer	**Number of sessions**	**Banister's TRIMP**	**Edward's TRIMP**	**Number of sessions**	**Banister's TRIMP**	**Edward's TRIMP**
F1	13	0.92**	0.96**	13	0.98**	0.98**
F2	7	0.98*	0.98*	18	0.89*	0.92*
F3	14	0.89**	0.92**	8	0.98**	0.98**
F4	6	0.85**	0.96**	13	0.97**	0.98**
F5	8	0.93**	0.98**	9	0.99**	0.99**
F6	8	0.95**	0.98**	23	0.97**	0.97**
F7	11	0.84**	0.91**	17	0.99**	0.96**
Mean	9.6	0.91	0.96	14.4	0.97	0.97
Range	41791.00	0.84 - 0.98	0.91 – 0.98	45139	0.89 - 0.99	0.92 – 0.99

The average values and correlations between the sRPE and HR-based methods across modes of training (footwork and sparring) and competition stages (poules and knockouts) are presented in Table 4. Significant correlations were found between the sRPE and both HR-based methods for all training modes (r = 0.73 – 0.85) and competition stages (r = 0.82 – 0.92).

Table 4 - Mean training loads & correlations for the sRPE method and HR-based methods for training (footwork & sparring) and competition (poules & KO). Values are presented as mean ± SD, significant at * *p* < 0.05, ***p* < 0.01, sRPE = session rating of perceived exertion (AU = arbitrary unit).

	Mode of Exercise	**# sessions/ competitions**	**sRPE Load (AU)**	**Banister's TRIMP**	***r***	**Edward's TRIMP (AU)**	***r***
Training	Footwork	67	93 ± 46	28 ± 20	0.73*	38 ± 26	0.79**
	Sparring	67	525 ± 251	98 ± 45	0.76*	200 ± 82	0.85**
Competition	Poules	85	31 ± 16	15 ± 5	0.82*	21 ± 7	0.89**
	KO	12	137 ± 49	47 ± 16	0.92*	67 ± 26	0.91**

Figure 1 shows a similar pattern between the sRPE and both HR-based methods (Banister's and Edward's TRIMP) throughout the testing period, with each training session representing the summation of one or more training modes, or several poules and knockouts in the case of competitions.

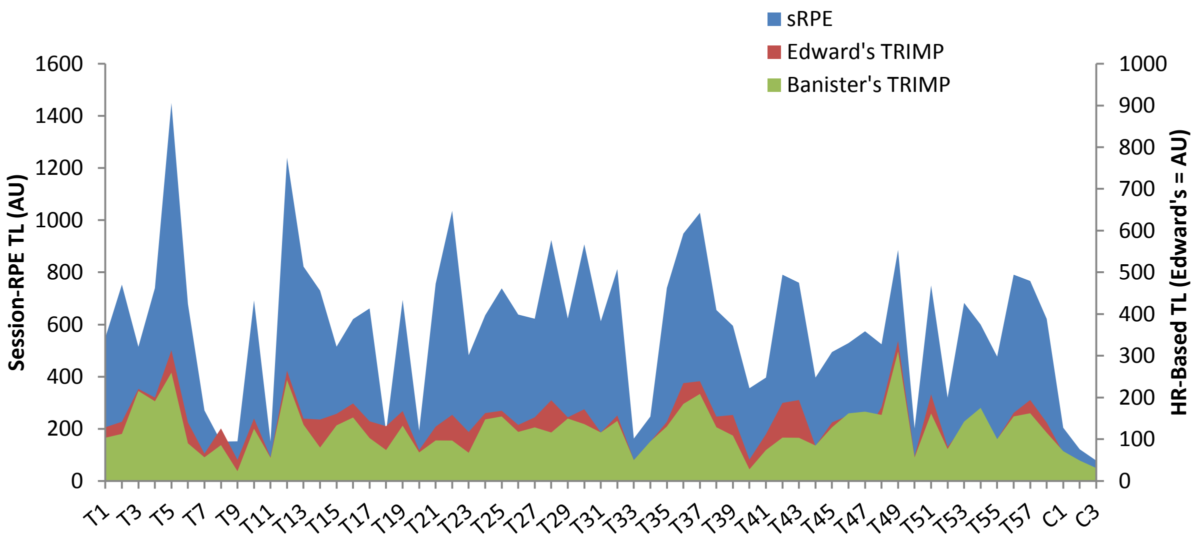

Figure 1 - Profile of the average sRPE vs HR-based TL methods across all training sessions and competitions during the season. sRPE load = session rating of percieved exertion load (AU = arbitrary unit).

DISCUSSION

This is the first study to investigate the use of the sRPE method as a simple and practical tool to quantity TL in fencing, by examining the similarity between the sRPE and HR-based methods (Banister's and Edward's TRIMP) during actual fencing training and competition. In line with the hypothesis of this study, data revealed significant correlations for each fencer (Banister's [r = 0.84 – 0.99] and Edward's TRIMP [r = 0.91 – 0.99]) and across each mode of exercise (Banister's [r = 0.73 – 0.76] and Edward's TRIMP [r = 0.79 – 0.85]) and stage of competition (Banister's [r = 0.82 – 0.92] and Edward's TRIMP [r = 0.89 – 0.91]. These results are consistent with previous investigations utilising athletic populations.[6,13-16,19-21]

Reliability for the sRPE using the ICC was poor 24 but all tests reported good CV's. To some extent, poor reliability within sRPE scores may be expected, as a change by only one unit on a 0-10 scale would represent a 10% change for an athlete; the slightly better ICC values for HR-based methods may therefore be explained by having a greater range of scores, and therefore less fluctuation (as a percentage) between each beat. Furthermore and affecting all methods, was that the external load between "identical sessions" could not be controlled to the same precision as treadmill running or cycling for example, where set speeds could be prescribed. However, even using this format Wallace et al.,[25] reported ICC and CV values of 0.73 and 28.1% respectively for sRPE, and 0.80 and 15.6 % respectively for Banisters TRIMP. The CV values for sRPE in their study, may have been higher simply on account of less within athlete agreement between scores, thus highlighting the importance of a familiarisation period and ensuring athlete's are well rested. Alternatively, it may be due to error by virtue of calculating the CV using Microsoft Excel and the "average" function for example. Because exertion scores change on a 10-point scale, it may be better to input changes manually as for example, via Microsoft Excel, the difference between scoring a session as a 7 or 8 will produce a difference of 13% and a CV of 9%. However, the difference between scoring a session as a 2 or 3 will produce a difference of 33% and a CV of 28%. Even averaging these out assuming they were part of a squad would give 18.5 % instead of 10%. Assuming scores only differed by 1 unit, then the CV should never exceed 10%, only dropping if any athletes are in absolute agreement with their previous score and thus obtained a CV of 0%. This zero would then be averaged in and reduce the CV proportionately. This highlights how data can be reliable by virtue of the ICC but not the CV. Here we believe the data should be considered reliable given the CV scores, where we can manually account for such a small range in scores.

In conclusion, we believe that the sRPE method of monitoring TL is both valid and reliable within the sport of fencing. Given its established reliability and validity within gym and plyometric based sessions[8-10] and with with young athletes,[26] this also presents a seamless method to monitor TL across the many modes of training engaged in by the modern day fencing athlete. Given that it is free and simple to use, fencers of all levels can take advantage of this.

PRACTICAL APPLICATIONS

Based on the results of this study and previous research, the sRPE method is similar to HR-based methods when quantifying TL in fencing. This should be welcomed news for sport science practitioners, given that modern day athletes also engage in various strength and conditioning related practices that can not always be appropriately quantified by virtue of HR (for example resistance and plyometric training). Using the sRPE method enables a seamless inclusion of these within the calculation of total TL. Furthermore, its costless mode makes it applicable to all levels of fencer and its simplicity requires little time to input the data and little expertise in analysing it. Finally, in fencing, HR devices are likely to be damaged on account of regular blunt force trauma via the sword.

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